# Nutritional diseases: from bottle feeding to geriatric issues

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# NUTRITIONAL DISEASES: FROM BOTTLE FEEDING TO GERIATRIC ISSUES

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From neonates that have to be hand-raised to animals beyond their prime that have difficulties ingesting the regular diet for their species, all animals at a zoo have to be fed, mostly on a daily basis. The decision what is fed is based on various concepts, often summarised as the juxtaposition of the concept of a complete (formulated) diet and a diet consisting of 'natural' diet items, illustrated in the articles of RATCLIFFE (1966) and WACKERNAGEL (1966) on the one hand and that of HEDIGER (1966) on the other. When arguing about the differential use of pelleted diets or roughages, or mineralised minced meat vs. whole carcasses, this debate remains alive today. However, as goes nearly without saying, the decision what is fed is most often based on what has been fed before. In the preparation of husbandry guidelines, for example, it can still often be seen that the feeding chapter merely comprises an inventory of what is currently being fed at various zoos rather than a recommendation of what should be fed. A confusion of actual recommendations and summaries of current practices may make introducing dietary changes more difficult.

Different approaches are used to investigate nutrition-related problems in zoo animals. A first step is an evaluation of the diets fed in captivity and a comparison with the species' natural diet (e.g. SCHWITZER et al., 2009; TAYLOR et al., 2013), with speculative links to typical problems known in the species that are logical but lack empirical evidence in the form of proven association between the problem and the diet of individuals with that problem. Another approach is to compare clinical or pathological measures between free-ranging and captive animals (PAGLIA et al., 2000; FUJITA and KAGEYAMA, 2007; KAISER et al., 2009), with speculative links to typical diets ingested in the wild or fed in captivity but again without a proven association. As a step closer to making that association, cases or case series of diseases known to be nutrition-related from domestic veterinary medicine are described with their clinical and *post mortem* pathology, together with varying levels of details of the nutritional history (e.g. CLAUSS et al., 2009a; SCHILCHER et al., 2013); here, the link is more compelling, yet negative controls are often lacking. At an increasing level of complexity, investigations on a larger number of animals are performed, and risk factors for animals with and without a problem are identified, such as the occurrence of metabolic bone disease in koalas (*Phascolarctos cinereus*) and exposure to UVB light (PYE et al., 2013), the link between obesity and acyclicity in African elephants (*Loxodonta africana*) (FREEMAN et al., 2009), or a link between the amount of roughage investigated and faeces consistency in tapirs (CLAUSS et al., 2009b). Availability and reliability of both clinical and necropsy records, and records of the diets fed or ingested, are major limiting factors for such studies. The most sophisticated approach, evidently, are controlled experimental studies (e.g. HOBY et al., 2010; MCCUSKER et al., 2011). One difficulty in such studies is that the target problem may be difficult to demonstrate, if it is not related to a clear immediate deficiency (such as e.g. in metabolic bone disease MBD) but to long-term health effects (such as e.g. in subacute ruminal acidosis). Another difficulty evidently is the transfer of both, logical concepts and empirical results, into common husbandry practices. One of our favourite examples for this difficulty is the clear, experimental approach to iron storage disease (ISD) in marmoset by MILLER et al. (1997) that showed that iron levels above 350 ppm dry matter resulted in critical illness; yet, even in 2011 complete feeds for marmosets were promoted that contained declared iron levels above this value (CLAUSS and PAGLIA, 2012). There are examples where nutritional research led to immediate changes, such as in the

development of circulating vitamin E levels in rhinoceroses after the first presentation on the topic (CLAUSS et al., 2002), but other examples warn that measures have to be implemented to maintain alertness to problems after they have been recognised for once (BESSELMANN et al., 2008).

One factor that may limit the compliance of zoo managers to adopt recommended dietary strategies is the absence of evident, acute signs of disease or abnormality. In this respect, gorillas could be considered an interesting example. Subjectively, it appears that gorillas are the one primate species in which current recommendations to reduce the amount of unnatural diet items, such as commercial fruits, meat, grain or milk products (OFTEDAL and ALLEN, 1996; NRC, 2003; SCHWITZER et al., 2009), are widely followed, in contrast to many other primate species. This might be due to the fact that the problem of regurgitation/reingestion is particularly prominent in this species and (also) linked to diet (LUKAS, 1999); note that however, this problem is also reported in other great apes and may also be related to the same diet factors (BAKER and EASLEY, 1996; CASSELLA et al., 2012).

Another, and possibly the most critical factor that may limit the compliance of zoo managers to adopt recommended dietary strategies is the apparently banal fact that there is no easily accessible, comprehensive collection of these recommendations, in a form comparable e.g. to taxonomy-structured compendia on zoo animal medicine (FOWLER and MILLER, 2005). In older zoo literature and recommendations derived from it, lists of diet items that can be fed to animals are available (KRUMBIEGEL, 1976; ENGELMANN, 2006; BLASZKIEWITZ et al., 2009; GRUMMT and STREHLOW, 2009) without amounts or proportions, or collations of diets actually fed (RECHCIGL, 1977b; RECHCIGL, 1977a), but their value for the design of current diet regimes may be limited. There are excellent textbooks on comparative nutrition (ROBBINS, 1993; BARBOZA et al., 2009; CHEEKE and DIERENFELD, 2010) and also on more focused taxonomic groups (KLASING, 1998; HUME, 1999), including detailed scientific treatments of nutrient recommendations (NRC, 2003; NRC, 2007), but it is difficult and time-consuming to extract practical diet solutions from them. Various conference series, such as the Dr. Scholl conferences, the Comparative Nutrition Society proceedings (http://www.cnsweb.org), the Nutrition Advisory group proceedings and fact sheets (http://nagonline.net/), the Zoo Animal Nutrition book series of the European Nutrition Group (http://www.filander.de/zoo.html), or volumes 6, 16 and 39 of the International Zoo Yearbook all represent additional valuable resources, yet the difficulty remains that no summarizing collection exists in which, in a standardised and easily accessible format, recommended diets are given for relevant zoo animal taxa or groups. For current zoo animal nutrition, such a task is probably the most important next step. For the time being, the maybe best overview over zoo animal nutrition can be found in the five nutrition chapters of KLEIMAN et al. (1996), and in various textbooks for specific groups, e.g. for reptiles in CALVERT (2004b; 2004a) and DONOGHUE (2006). For the hand-raising of neonates, lists of milk composition are available (JENNESS and SLOAN, 1970; OFTEDAL, 1984) as well as various compilations (e.g. TAYLOR and BIETZ, 1982) and numerous individual articles, and there are commercial preparations designed to achieve any kind of milk nutrient composition (e.g. Zoologic Milk Matrix, http://www.petag.com/).

Species- or taxon-specific knowledge in the feeding of zoo animals is important, with various examples such as galactose intolerance that leads to cataracts in macropod joeys when fed lactose-containing milk (such as cow's milk) (STANLEY, 2002), the fact that vitamin $D_2$ has no effect on calcium absorption in new world monkeys which therefore require a source of vitamin $D_3$ (HUNT et al., 1967), or a particular proneness for copper deficiency in blesbok (DIERENFELD et al., 1988), to name just a few. On the other hand, several general themes are prevalent in zoo animal nutrition, such as MBD, ISD, obesity, and dental disorders, as well as the encouragement of natural behaviours (HOSEY et al., 2013). Whereas MBD is particularly affecting growing animals, the effects of obesity, ISD and dental disorders accumulate over time and therefore affect adult and geriatric animals. In particular, dental

abnormalities are common in very old animals (e.g. MARTIN JURADO et al., 2008), and dietary adjustment for this group often requires the presentation of diet items that can be ingested without intensive mastication (e.g. HATT et al., 2004). In particular, the prevention of obesity has received increased attention at recent zoo nutrition meetings, and regular body condition scoring and/or weighing of animals, with corresponding adjustments in diet, are widely recommended. Additionally, reports on collection-wide dietary changes, in particular with the aim of increasing dietary fibre, and reducing sugars (as in commercial fruit) and starches (as in grain-based products) have been presented (FIDGETT, 2012; HATT, 2012; TAYLOR et al., 2012; PLOWMAN, 2013) that demonstrate not only the feasibility of such large-scale changes, but also their cost-efficiency. Efforts to spread knowledge on the nutrient composition to zoo animal keepers to motivate and increase the acceptance of diet changes (e.g. CLAUSS et al., 2012) should continue; for example, a series of posters on the topic is available (also in English language) at the Dierenwelzijnsweb (http://www.groenkennisnet.nl/dierenwelzijnsweb/Pages/dierentuinvoeding.aspx). Last but not least, diets fed to zoo animals represent visible cues for zoo visitors on the biology of the species; in this respect, feeding diets of biological logic is an integral part of the pedagogic concept of a zoo.

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